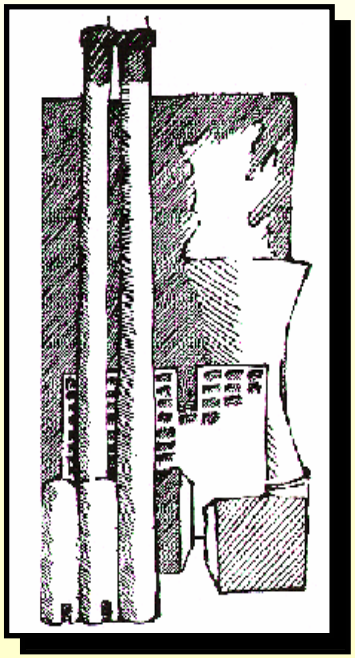
USE OF COAL DRYING TO REDUCE WATER CONSUMED IN PULVERIZED COAL POWER PLANTS

PROJECT DE-FC26-03NT41729



Project Team
Lehigh University – Prime Contractor
Great River Energy – Industrial Sponsor & Technical Collaborator

Dr. Edward Levy – P.I.
Dr. Nenad Sarunac – Co.P.I.

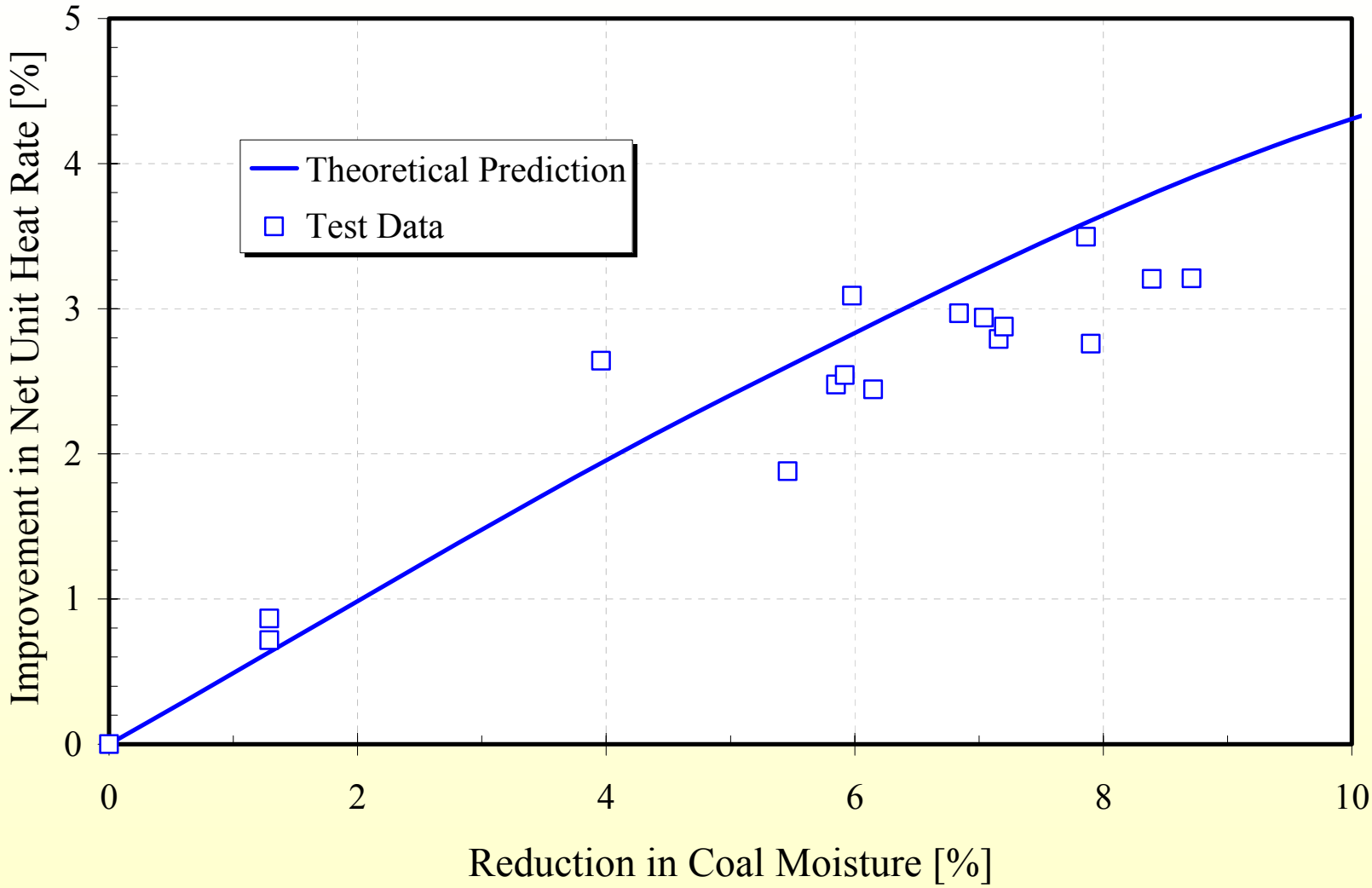
TYPICAL MOISTURE CONTENTS

Lignite	20 to 40%
Subbituminous	15 to 30%

BENEFITS OF DRYING

HEAT RATE

- Increased Heating Value of As-Fired Fuel
- Reduced Stack Loss
- Reduced Station Service Power
  - Mills
  - ID Fans



Improvement in Net Unit Heat Rate Versus Reduction in Coal Moisture Content

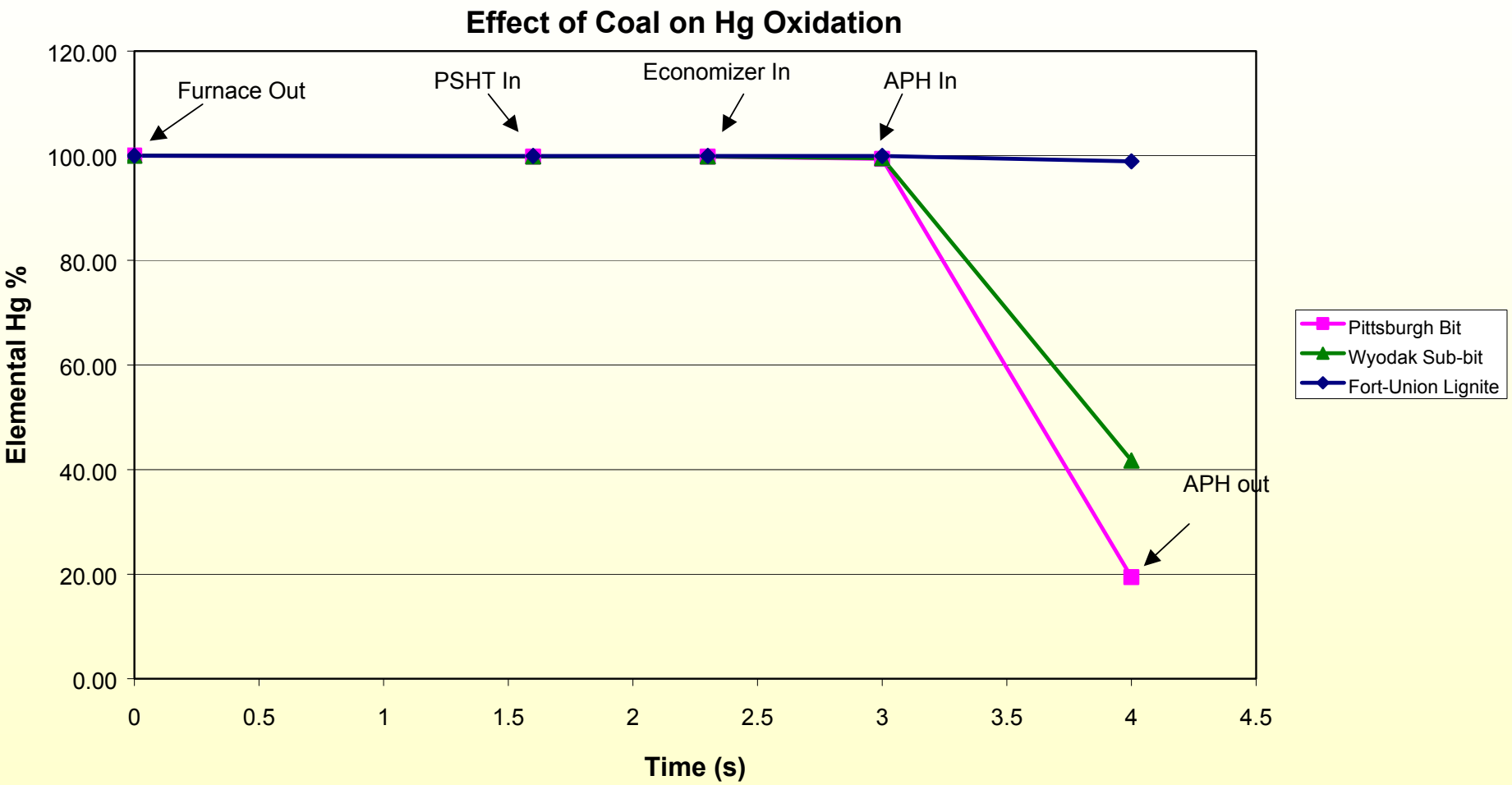
EMISSIONS

- SO_2, CO_2 – of Same Magnitude as ΔHR
- NO_x ?
- Hg ?

COOLING TOWER MAKEUP WATER

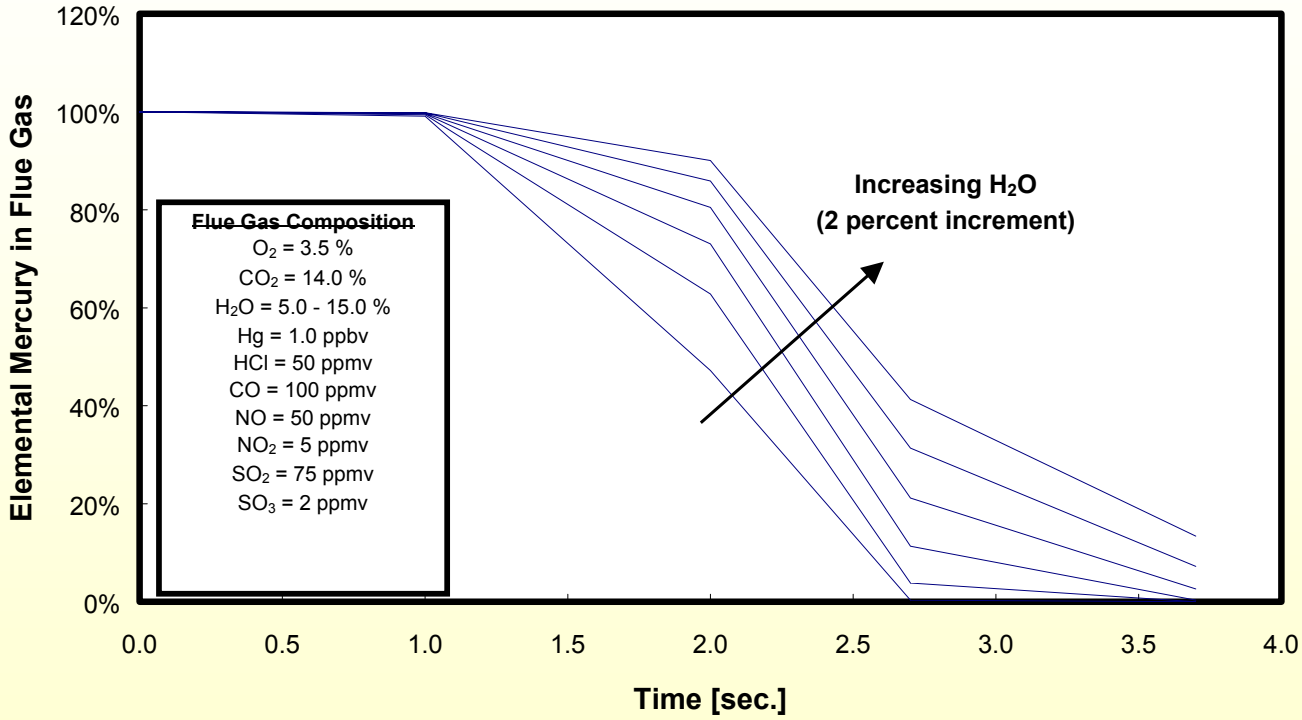
NO_x

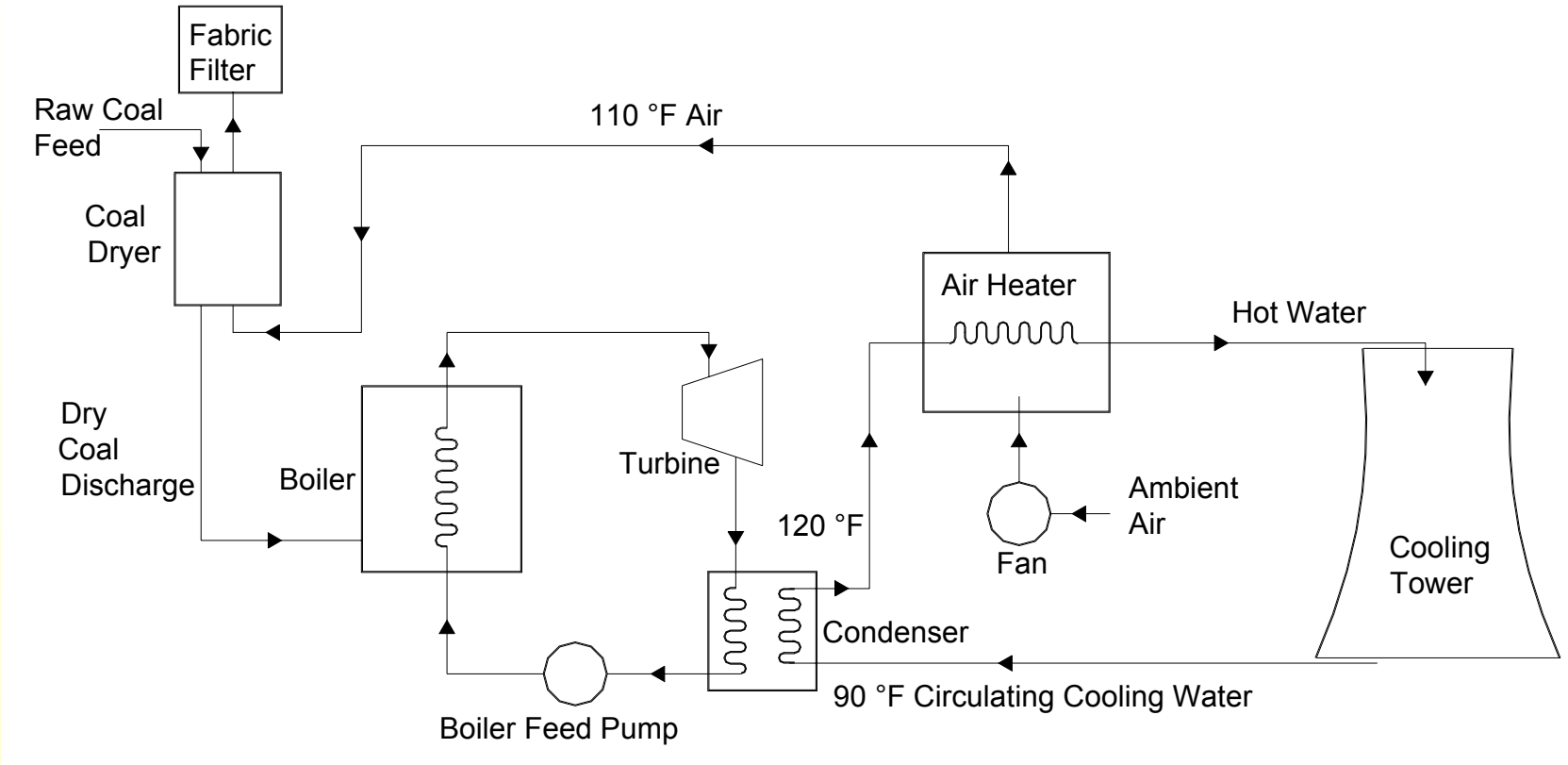
- Reduced Due to Lower Heat Rate
- Possibly Increased Due to Higher Furnace Temperature
- Need Field Tests to Determine Net Impact on NO_x


Effect of Coal on Hg Oxidation
Elemental Hg %
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Time (s)
Furnace Out
PSHT In
Economizer In
APH In
APH out
Pittsburgh Bit
Wyodak Sub-bit
Fort-Union Lignite

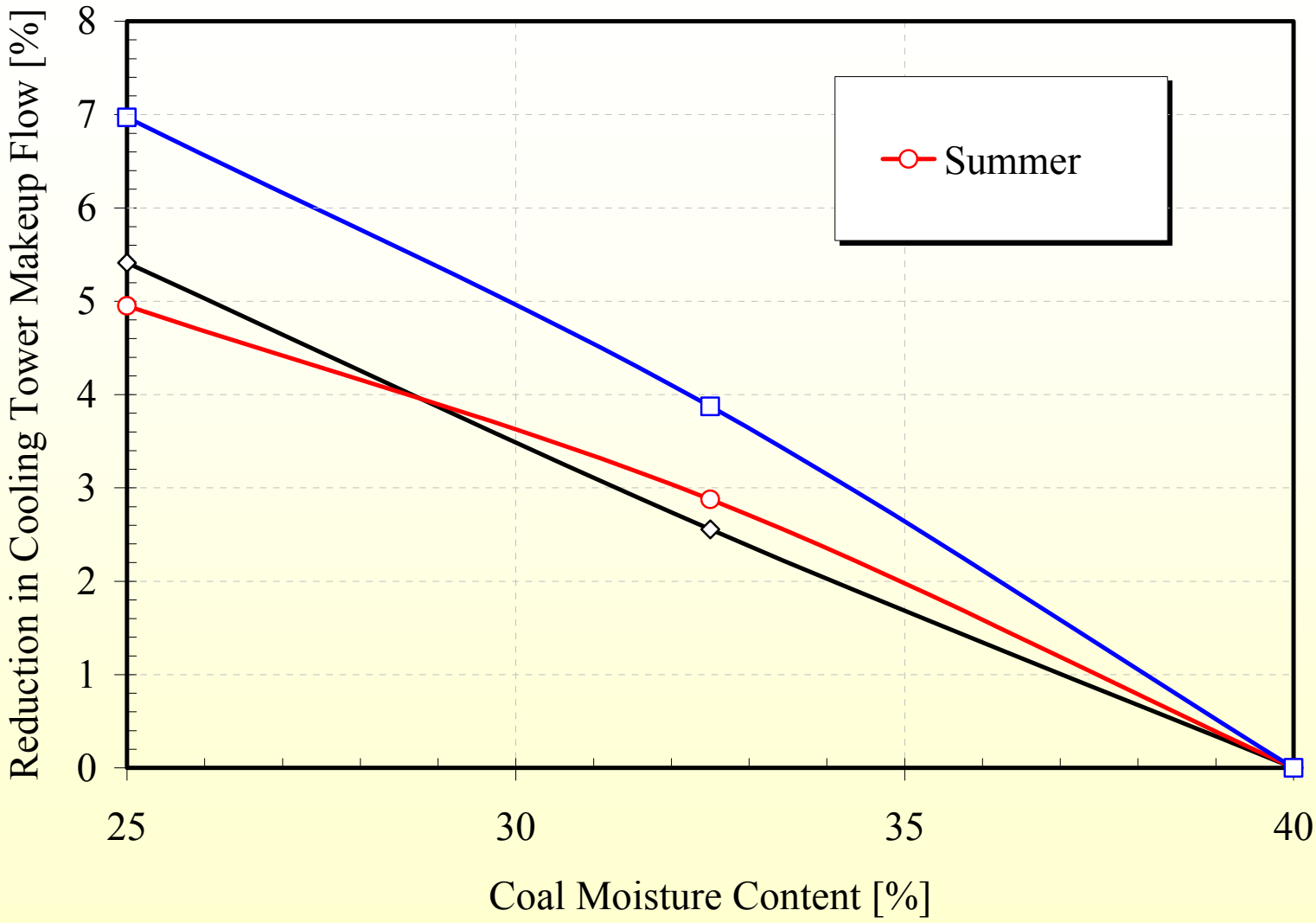
Mercury Chemical Kinetics

Effect of H_2O in Flue Gas on Elemental Mercury Reduction





Schematic of Plant Layout, Showing Air Heater and Coal Dryer (Version 1)



The Effects of Coal Moisture on Cooling Tower Makeup Water

OBJECTIVES

- Kinetics of Drying in Fluidized Beds and Fixed Beds
- Tradeoff Study of Drying Options
- Develop Optimized System Design
- Lignite and PRB Coal

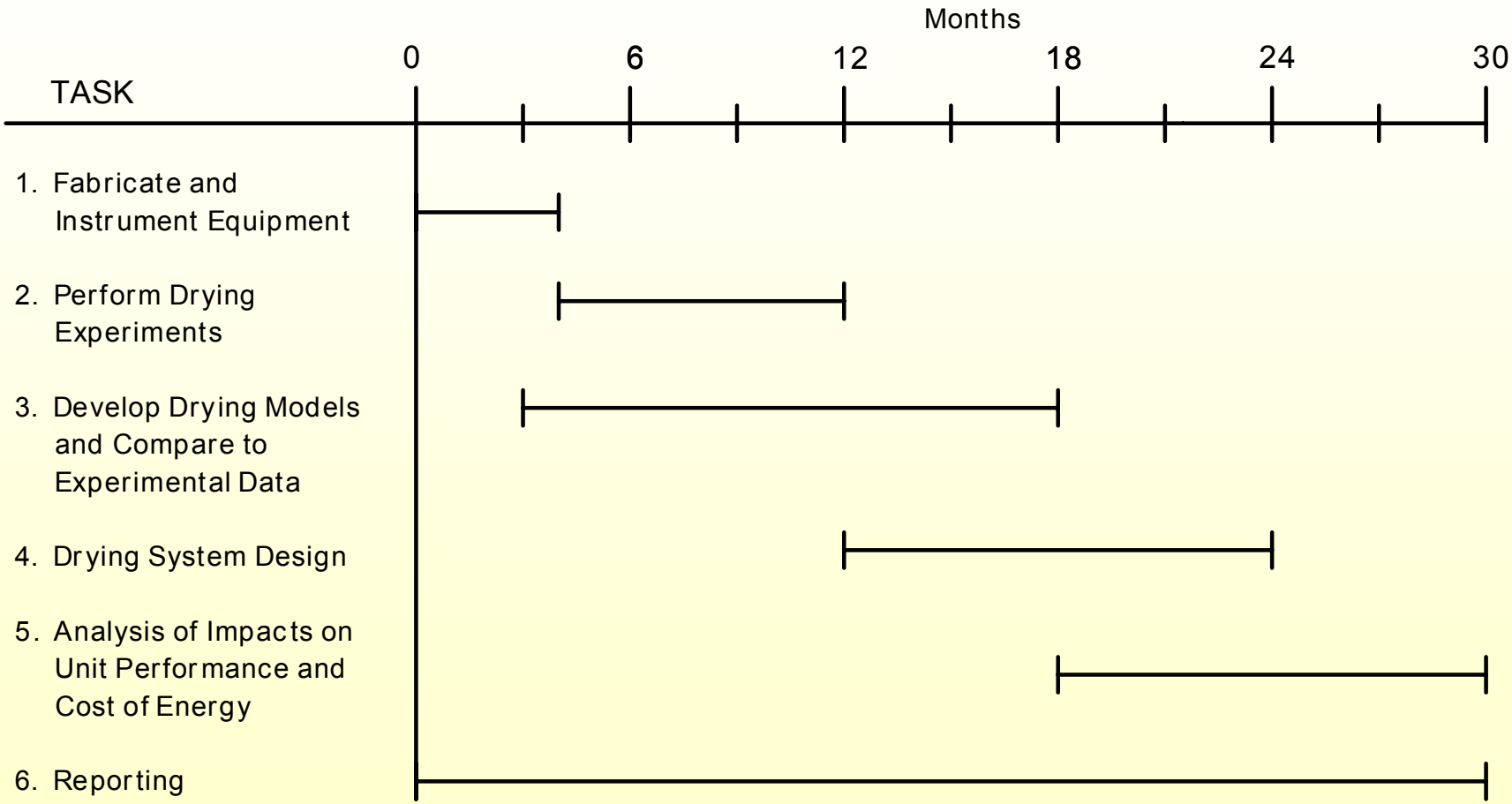
TASKS

- Perform Experiments to Measure Drying Kinetics of Lignite and PRB Coal

  Vary:

  - Particle Size Distribution
  - Superficial Air Velocity
  - Drying Temperature
  - Moisture Content of Inlet Air
  - Bed Depth
- Develop Drying Models
- Drying System Design
- Analysis of Impacts of Unit Performance and Cost of Energy

Project Schedule



PROGRESS TO DATE

- **Preaward Activities (Summer 2002)**

  Funding from GRE – Laboratory Fluidized Bed Drying Studies Generated the Data Needed for Pilot-Scale Fluid Bed Dryer Design.
- **DOE Contract Signed – December 26, 2002**

- **Progress on DOE Contract**

Task 1: Fabricate and Instrument Equipment

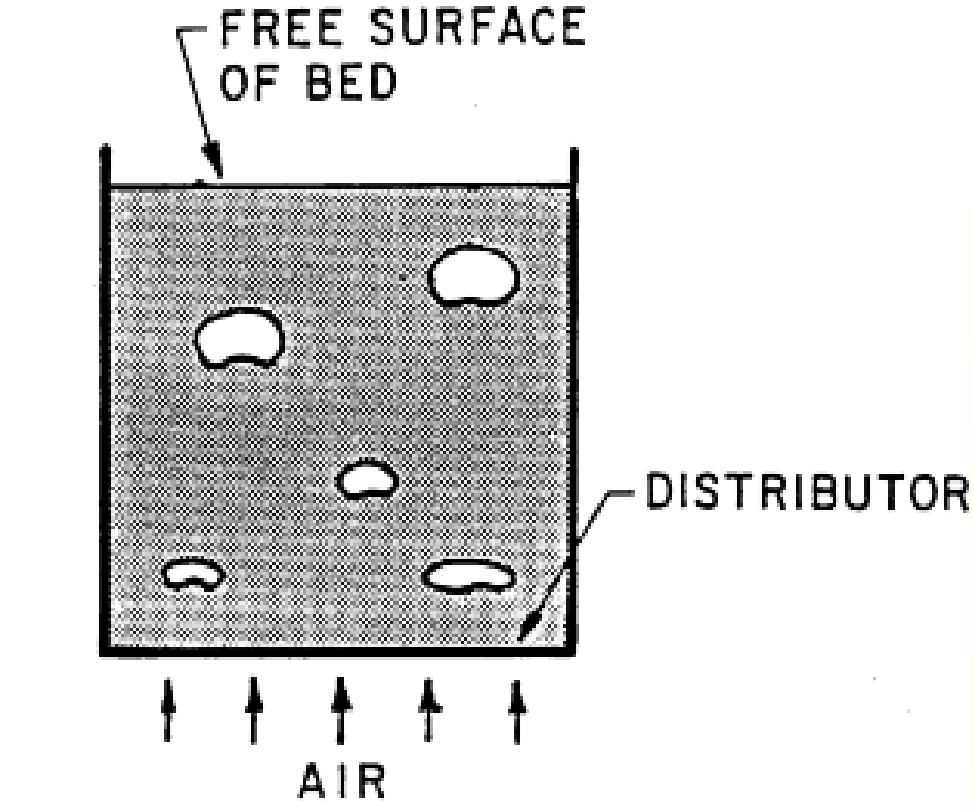
- ➢ **Modified Lab Setup**
  - **Instrumentation**
  - **Coal Removal Ports**
  - **Air Humidifier**

Task 2: Perform Drying Experiments

- ➢ **Fluidization Experiments – Effect of Velocity**

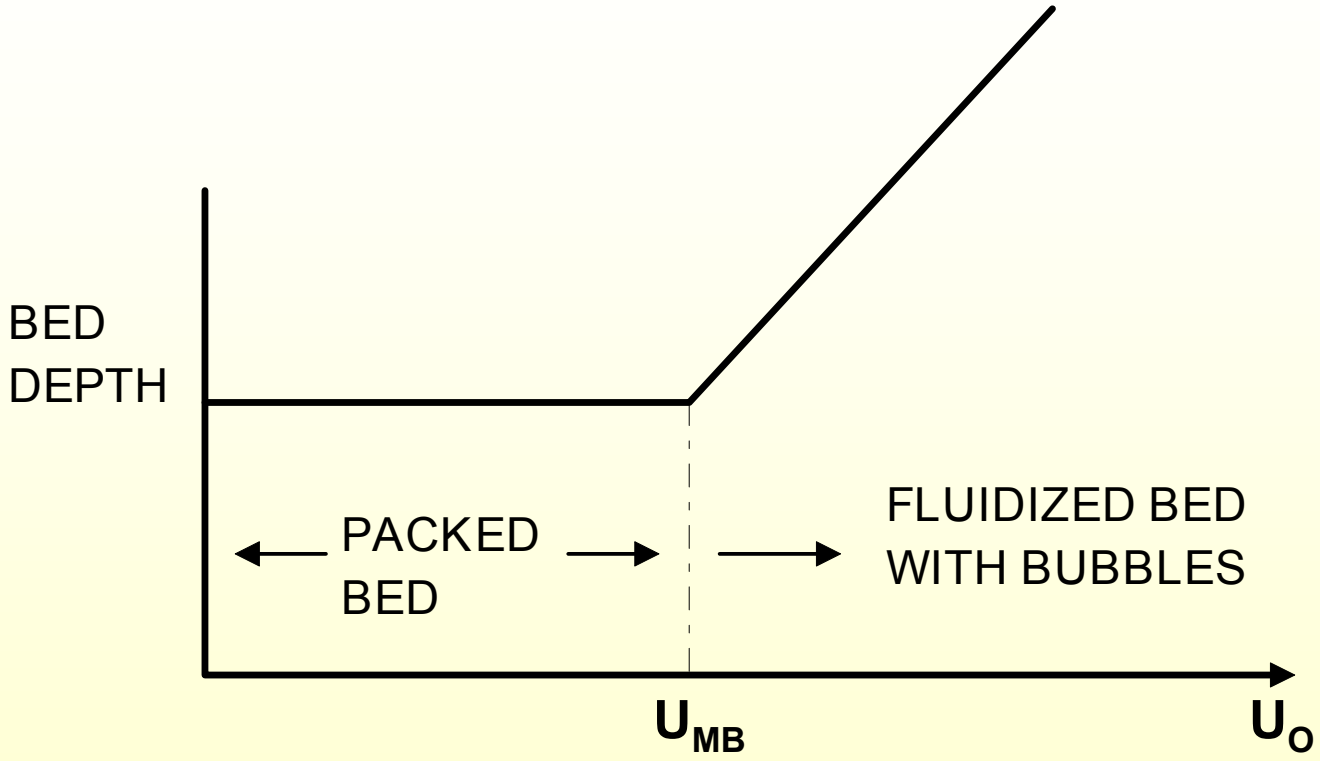
Task 3: Drying Models

- ➢ **Review Literature on Drying Models**

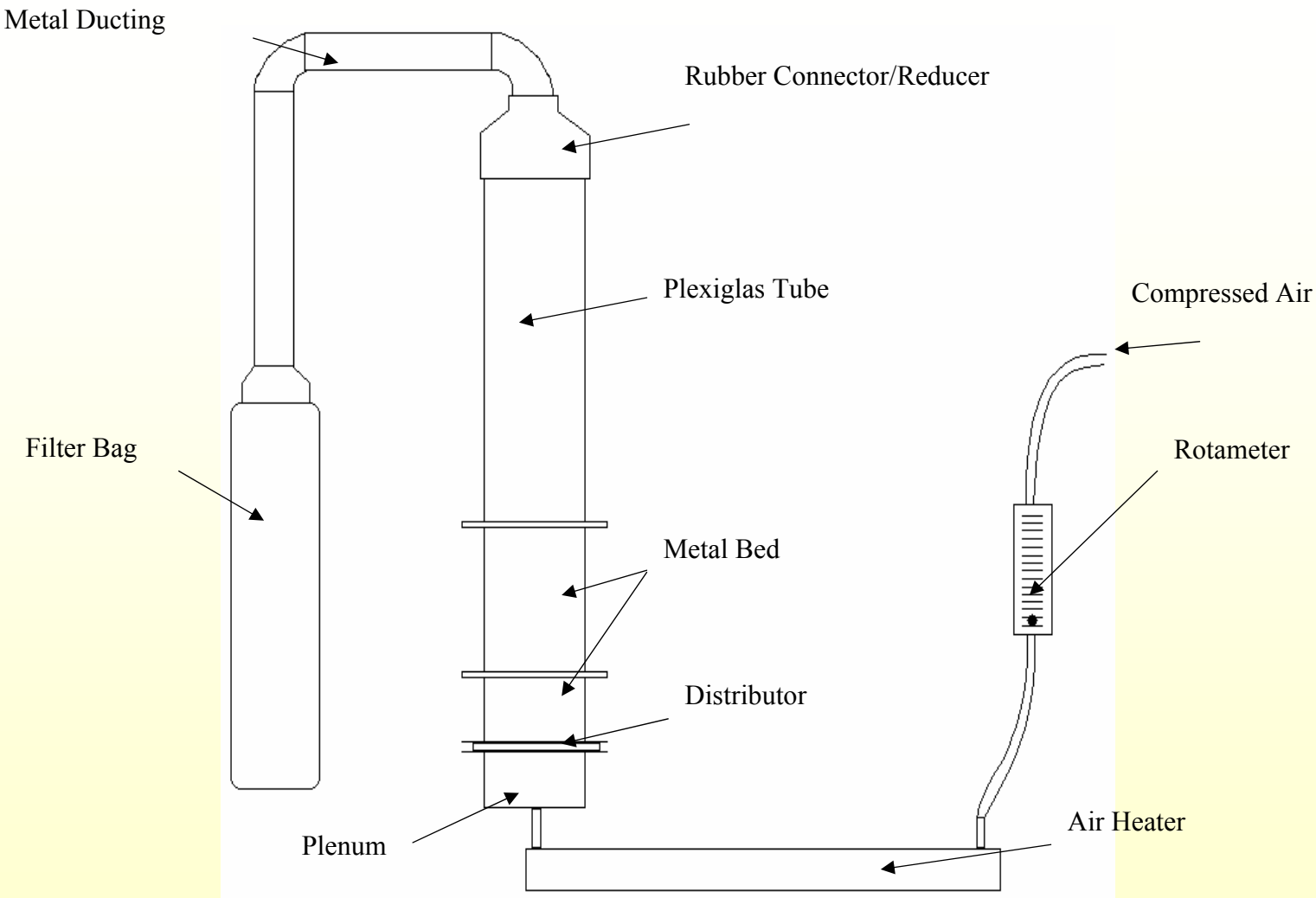


Sketch of Bubbling Fluidized Bed

FLUIDIZED BED TERMINOLOGY



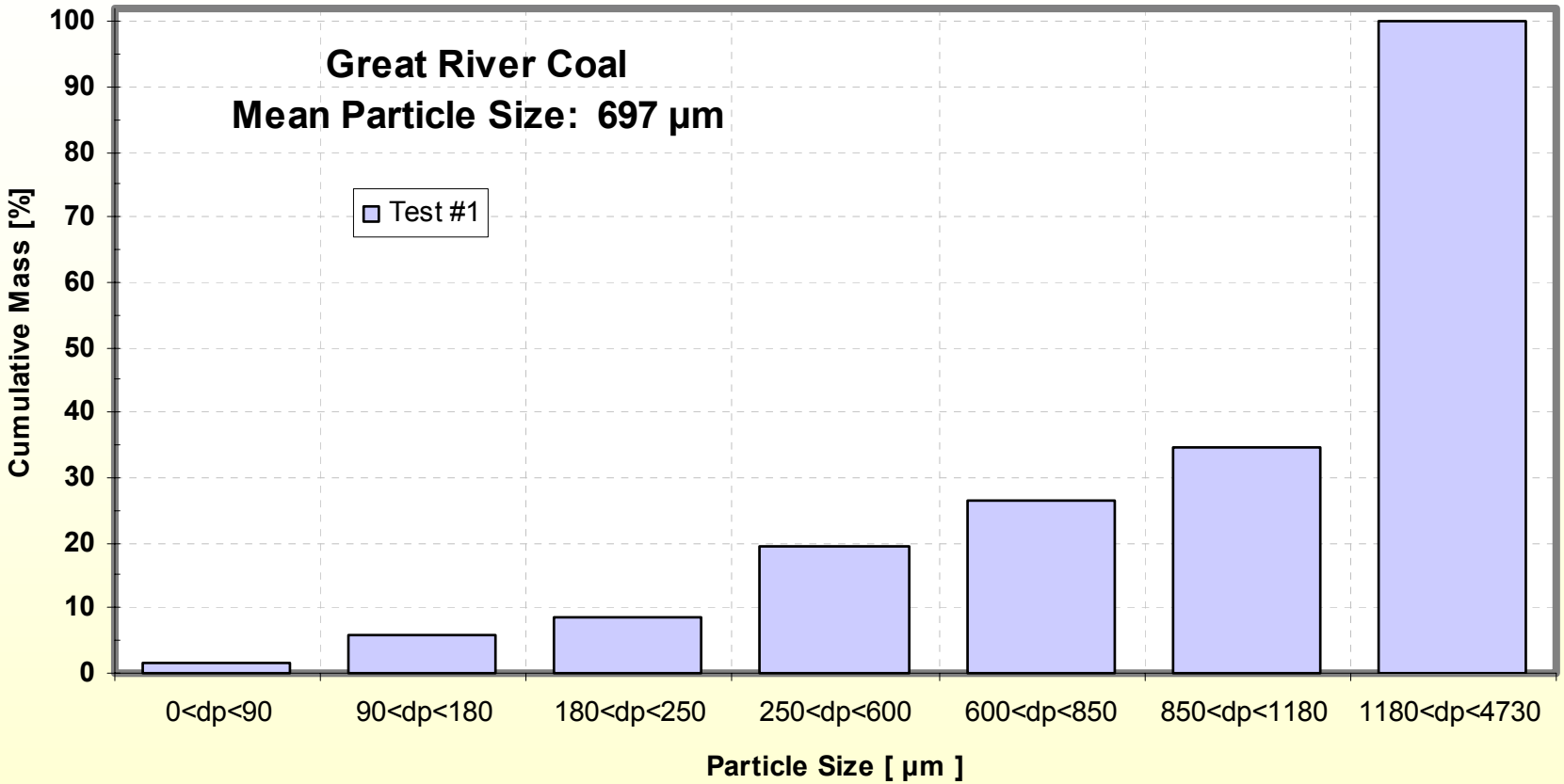
U_O - Superficial Gas Velocity
U_{MB} - Minimum Bubbling Velocity
$U_O - U_{MB}$ - Excess Gas Velocity



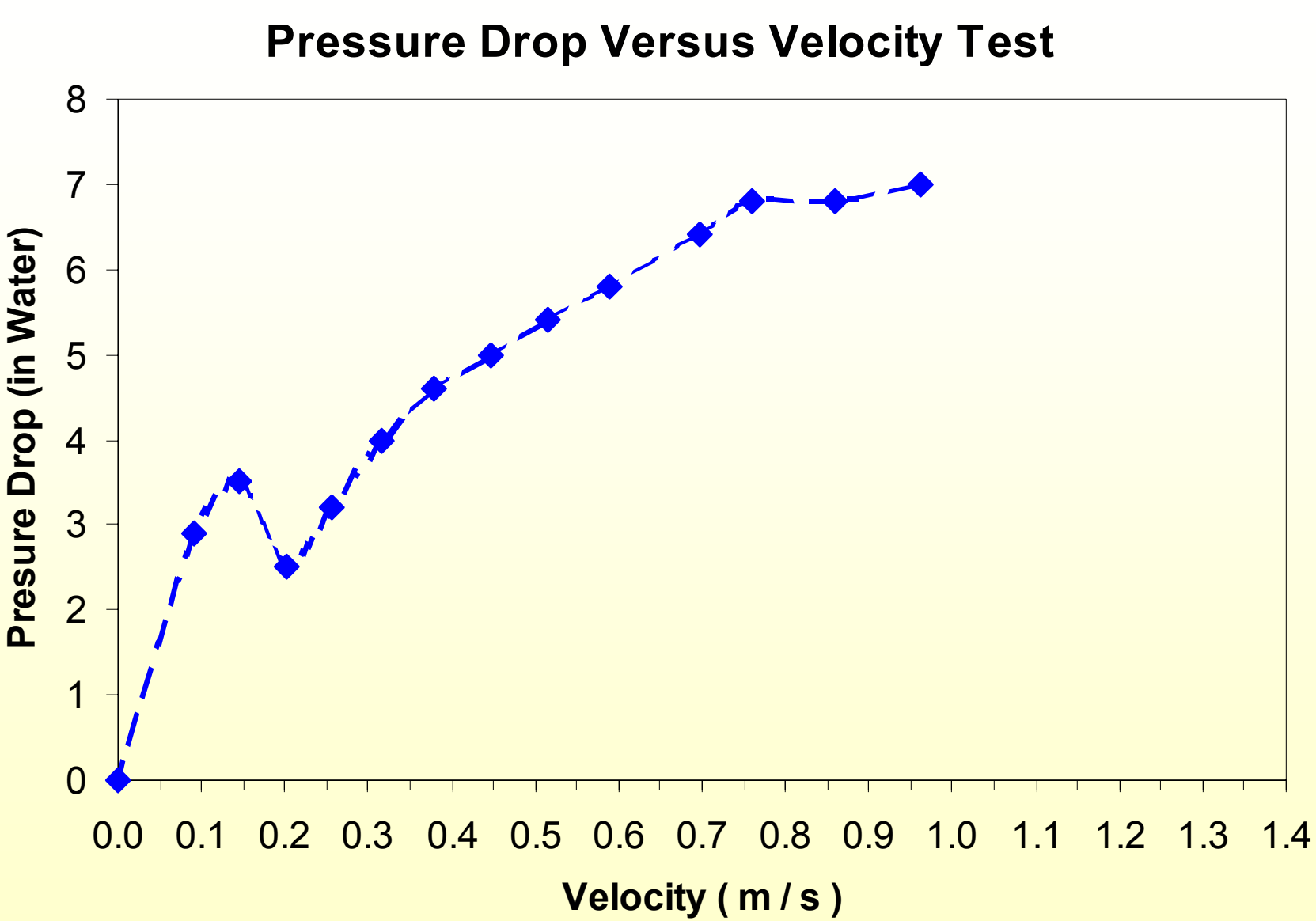
Sketch of Experimental Bed Setup

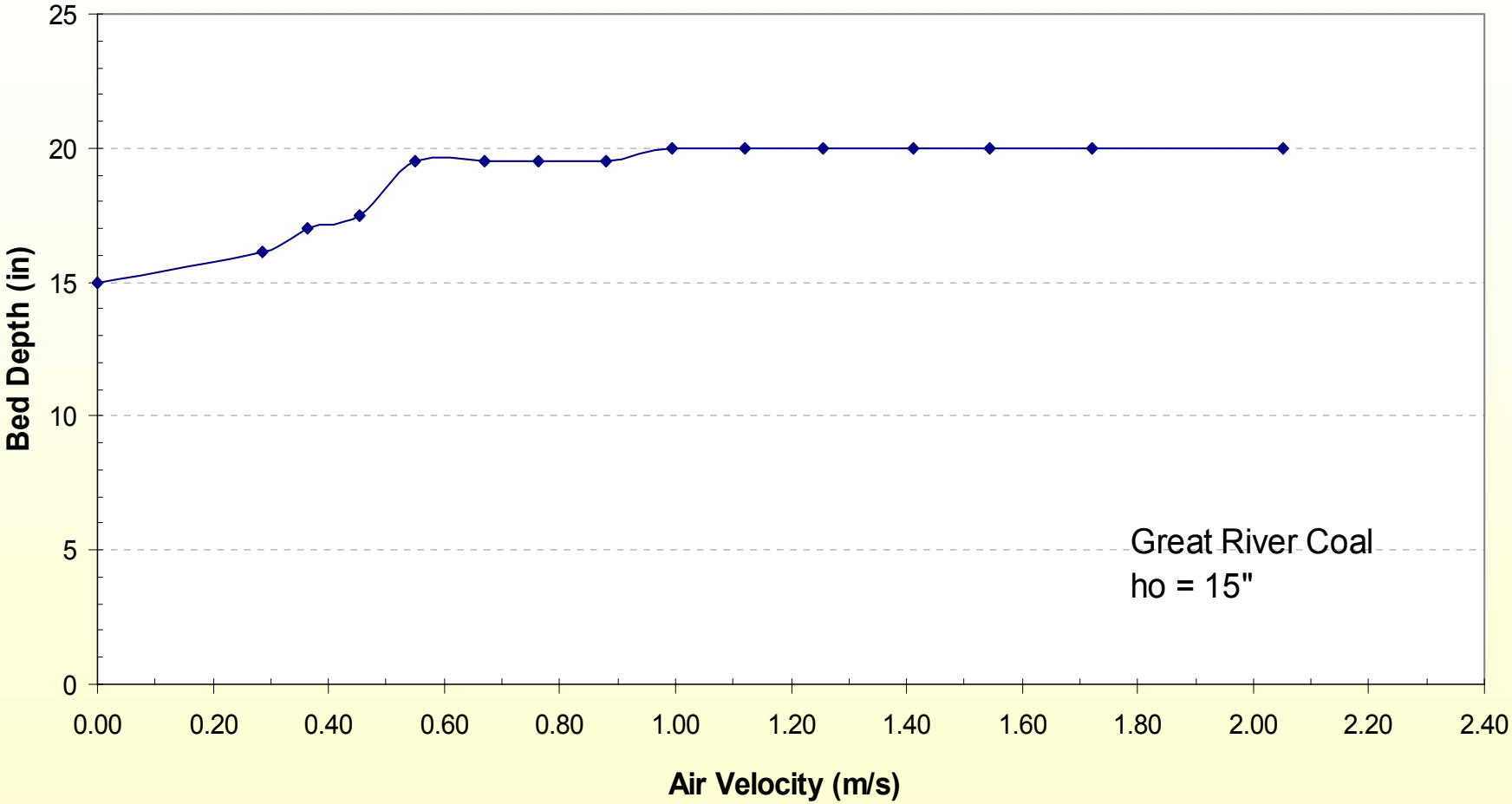
Fluidized bed has immersed electrical heaters to simulate heat exchanger bundle with hot circulating water.

Crushed coal ~ ¼” top size.

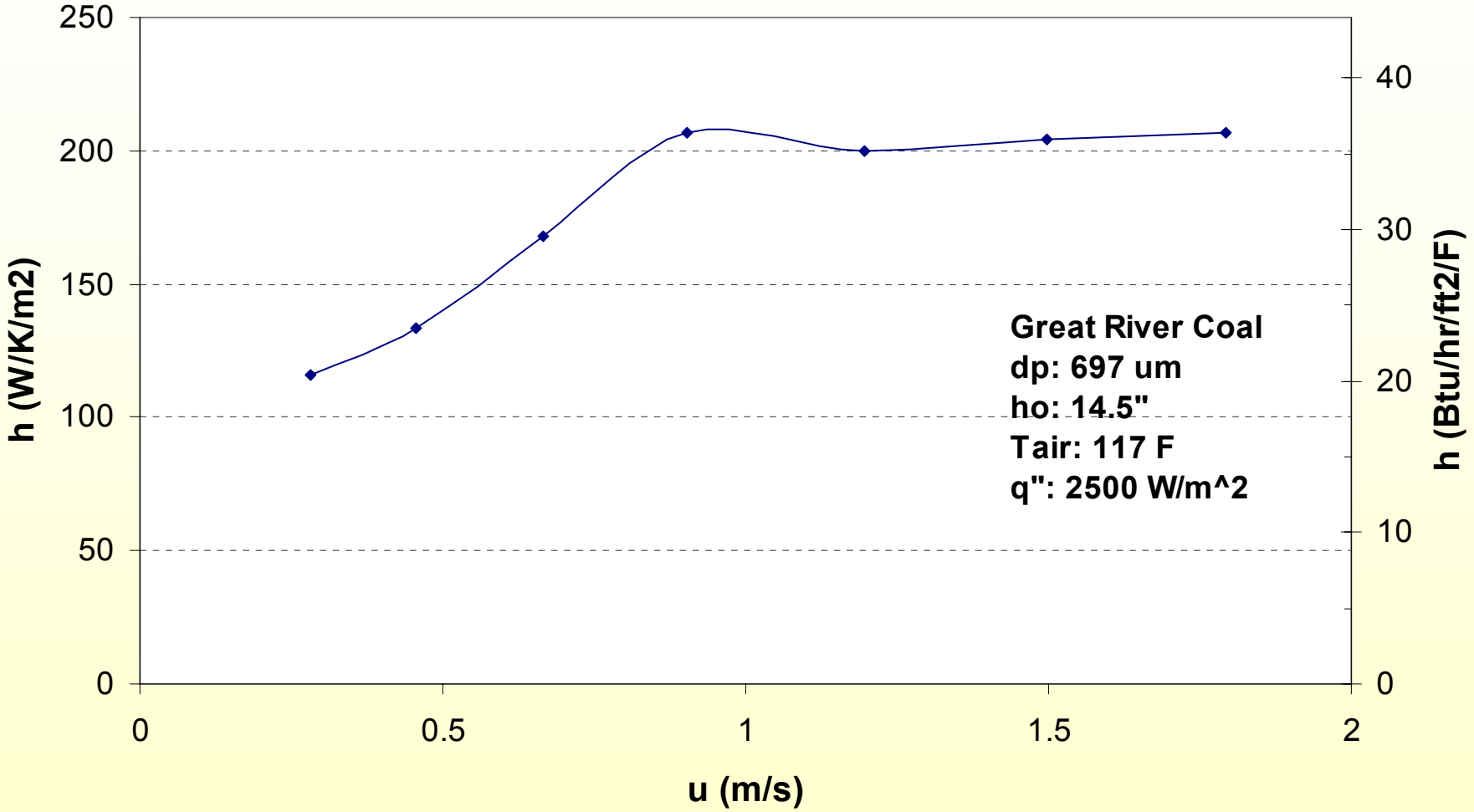


Cumulative Mass Distribution

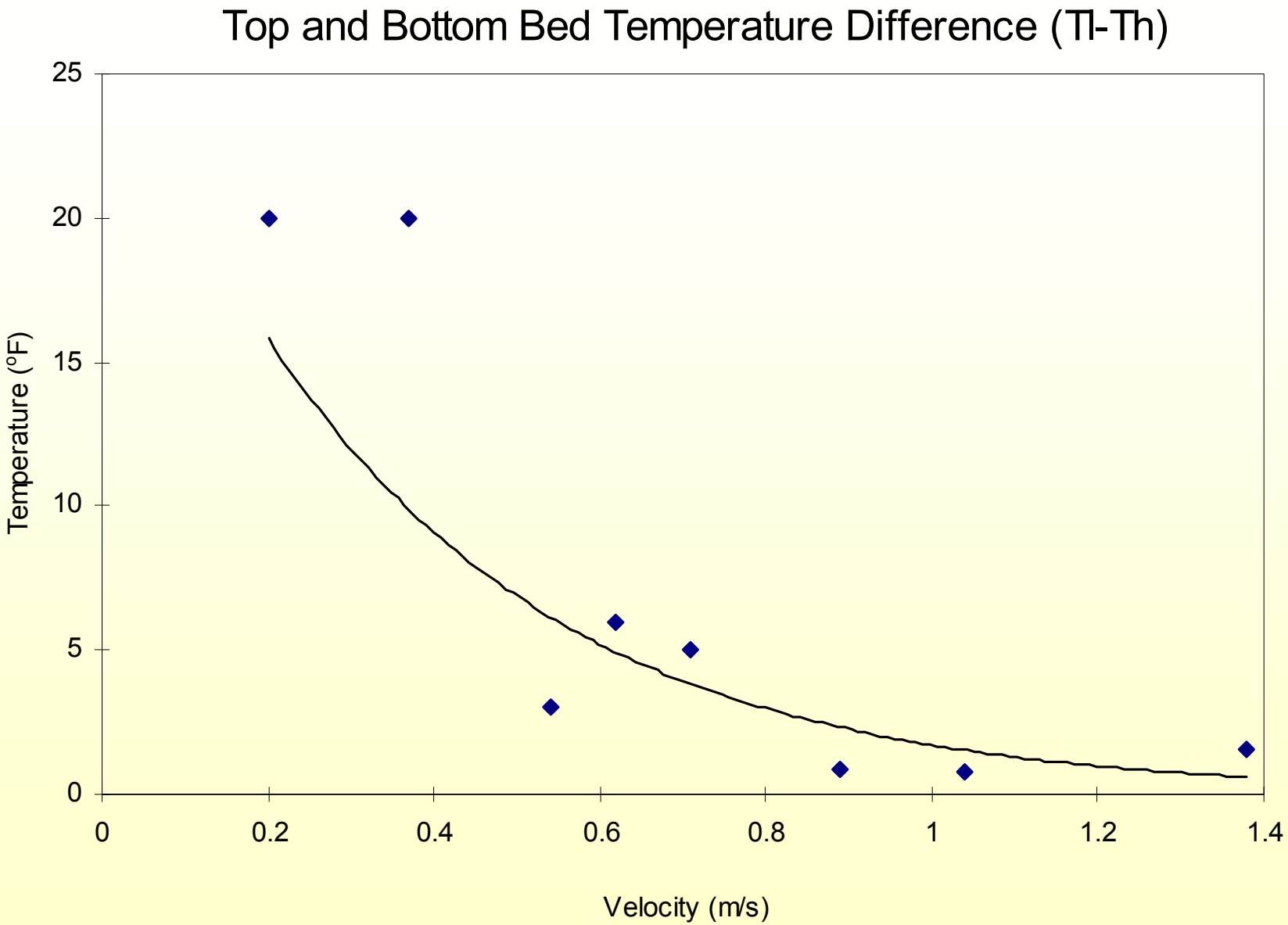

Pressure Drop Versus Velocity Test
Presure Drop (in Water)
0
1
2
3
4
5
6
7
8
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
Velocity (m / s)

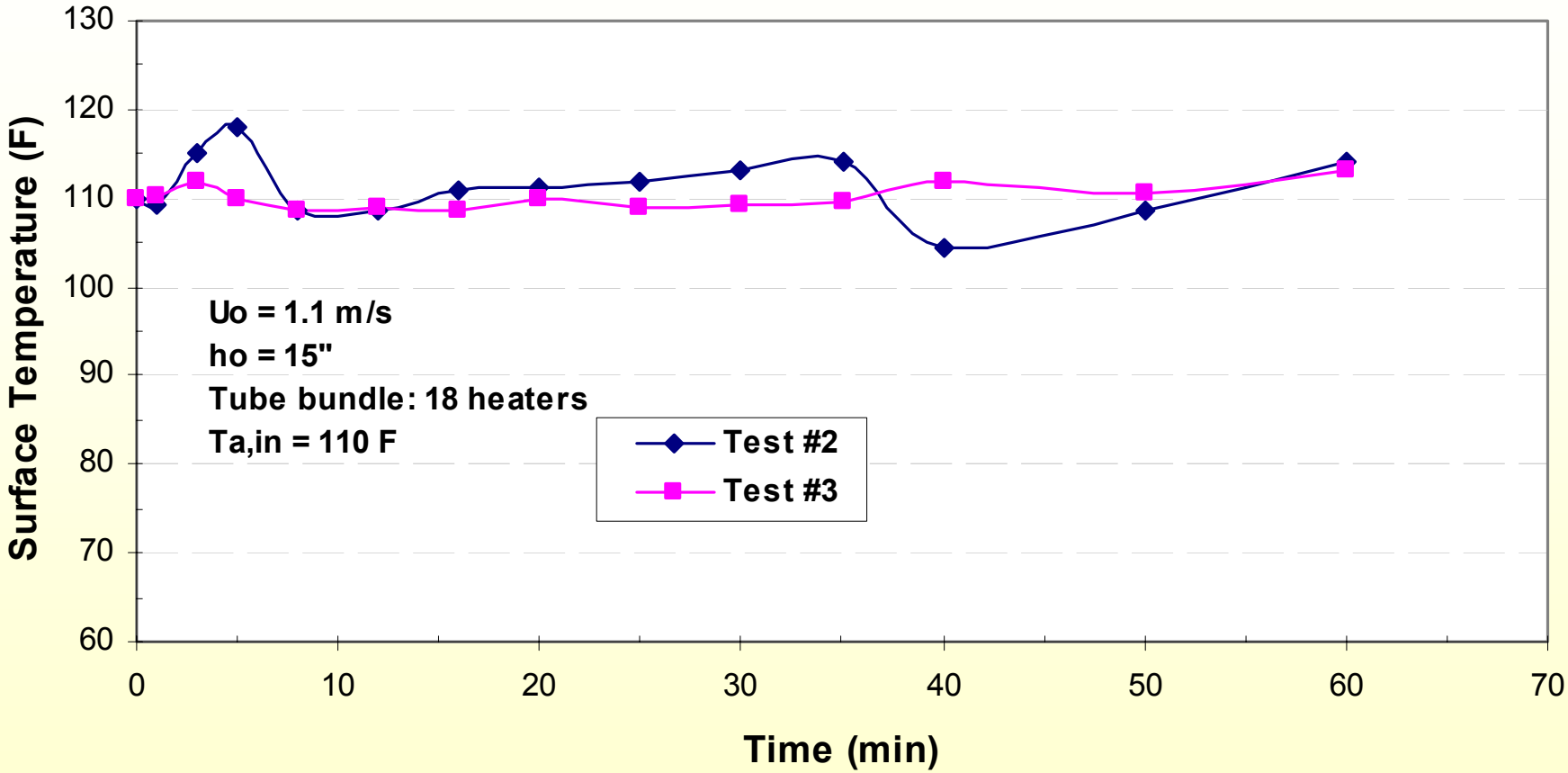


The Variation of Bed Depth with Superficial Air Velocity

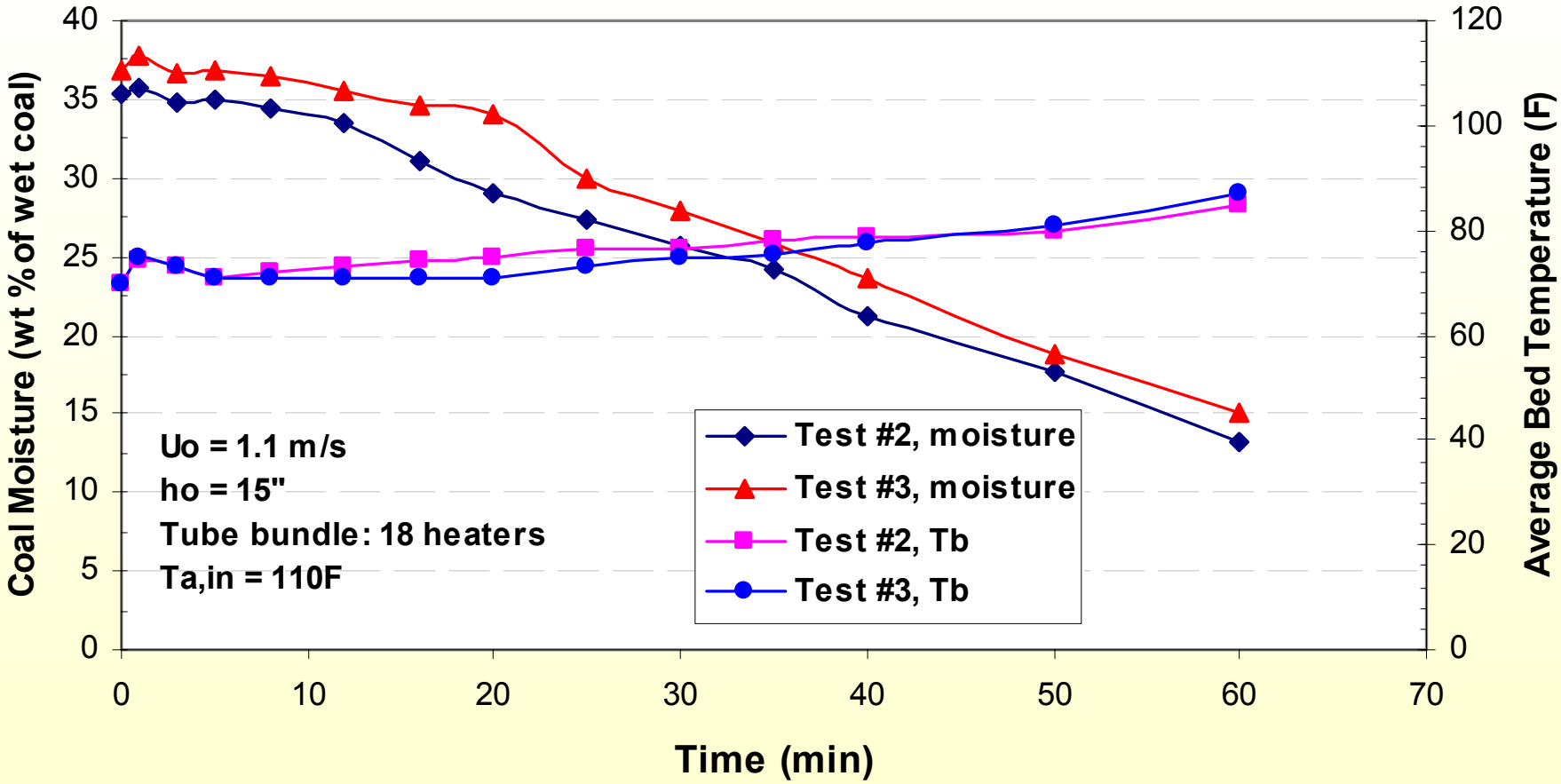


Heat Transfer Coefficient Versus Air Velocity

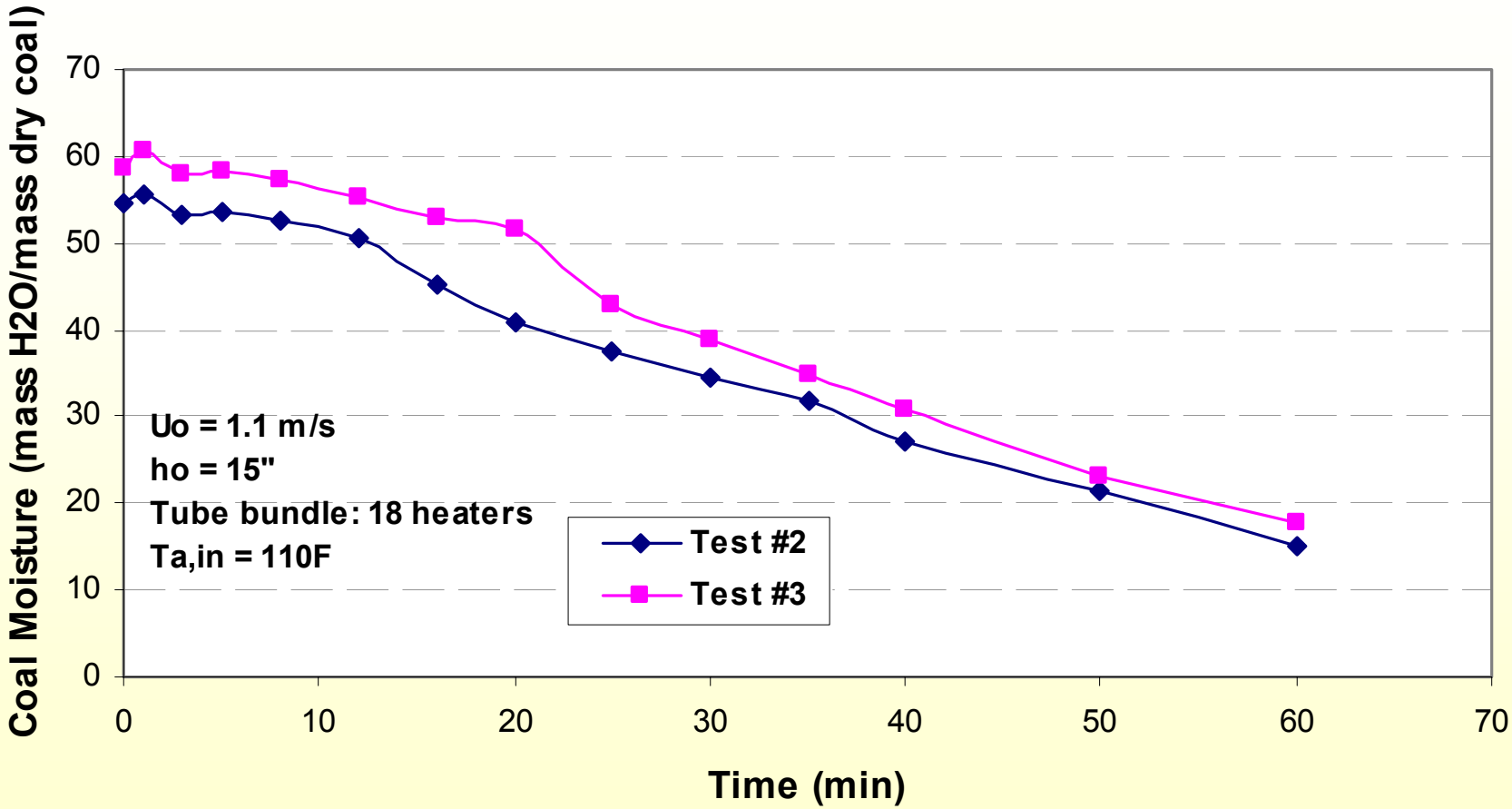

Top and Bottom Bed Temperature Difference (Tl-Th)
Temperature (°F)
25
20
15
10
5
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Velocity (m/s)



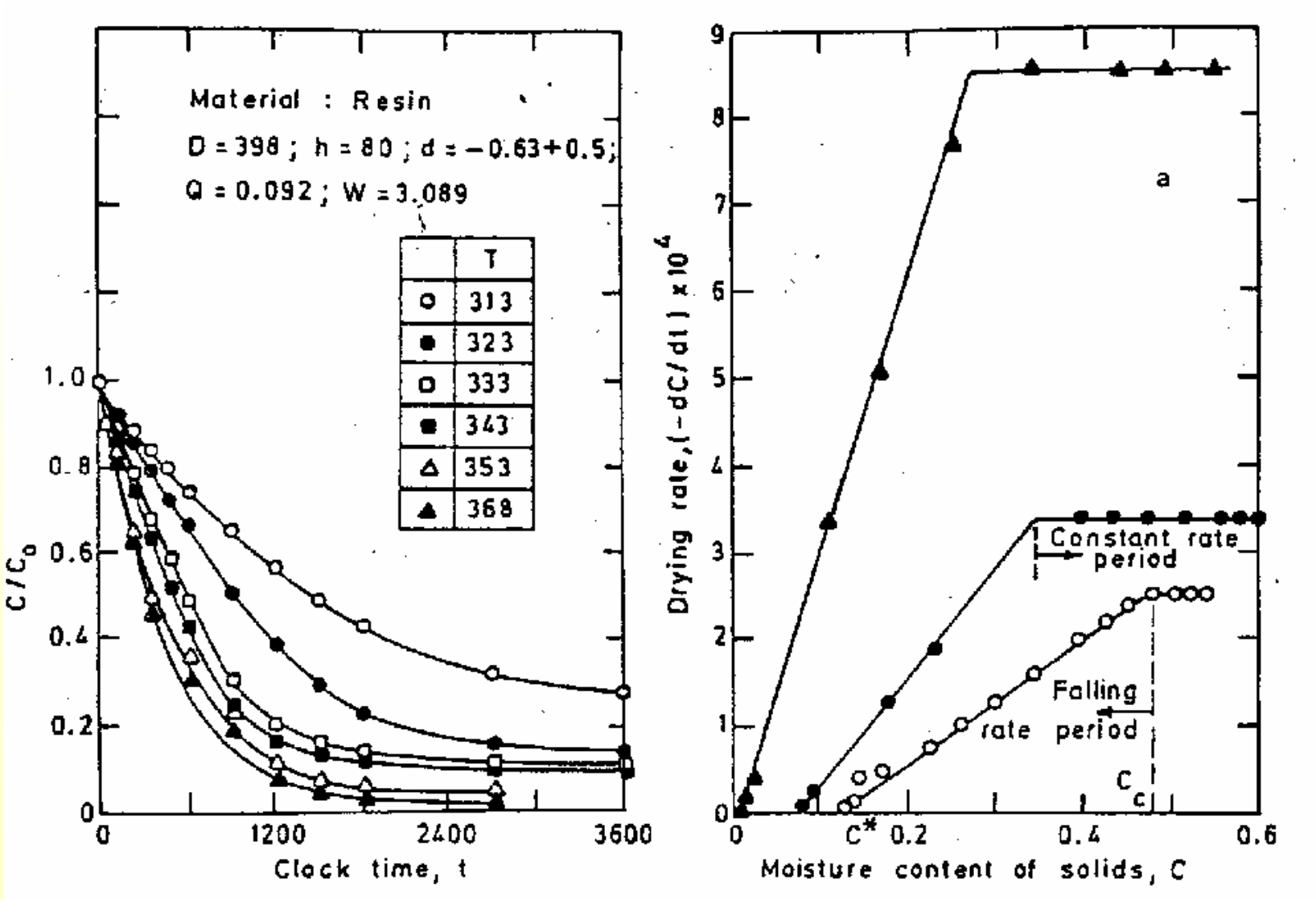
Tube Surface Temperature Versus Time



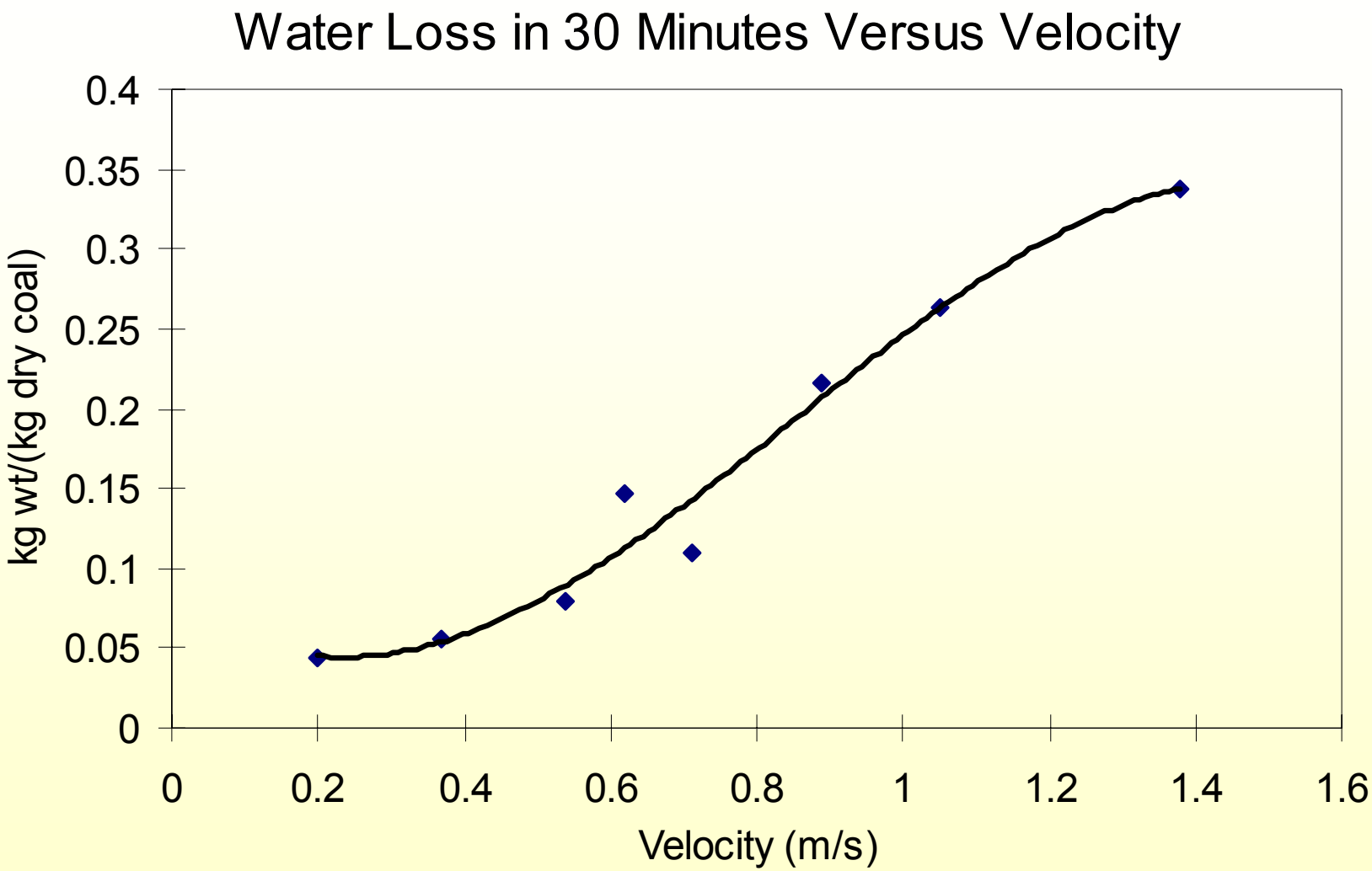
Coal Moisture Versus Time (wt % of wet coal)



Coal Moisture Versus Time (wt % of dry coal)



Relative Moisture Content of Solids with System Variables: Effect of Drying Temperature (15)


Water Loss in 30 Minutes Versus Velocity
kg wt/(kg dry coal)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
Velocity (m/s)

ADDITIONAL EXPERIMENTS:

- Particle Size
- Drying Temperature
- Moisture Content of Inlet Air
- Bed Depth
- Lignite & PRB
- Packed Versus Fluidized Bed

TASK 4: DRYING SYSTEM DESIGN

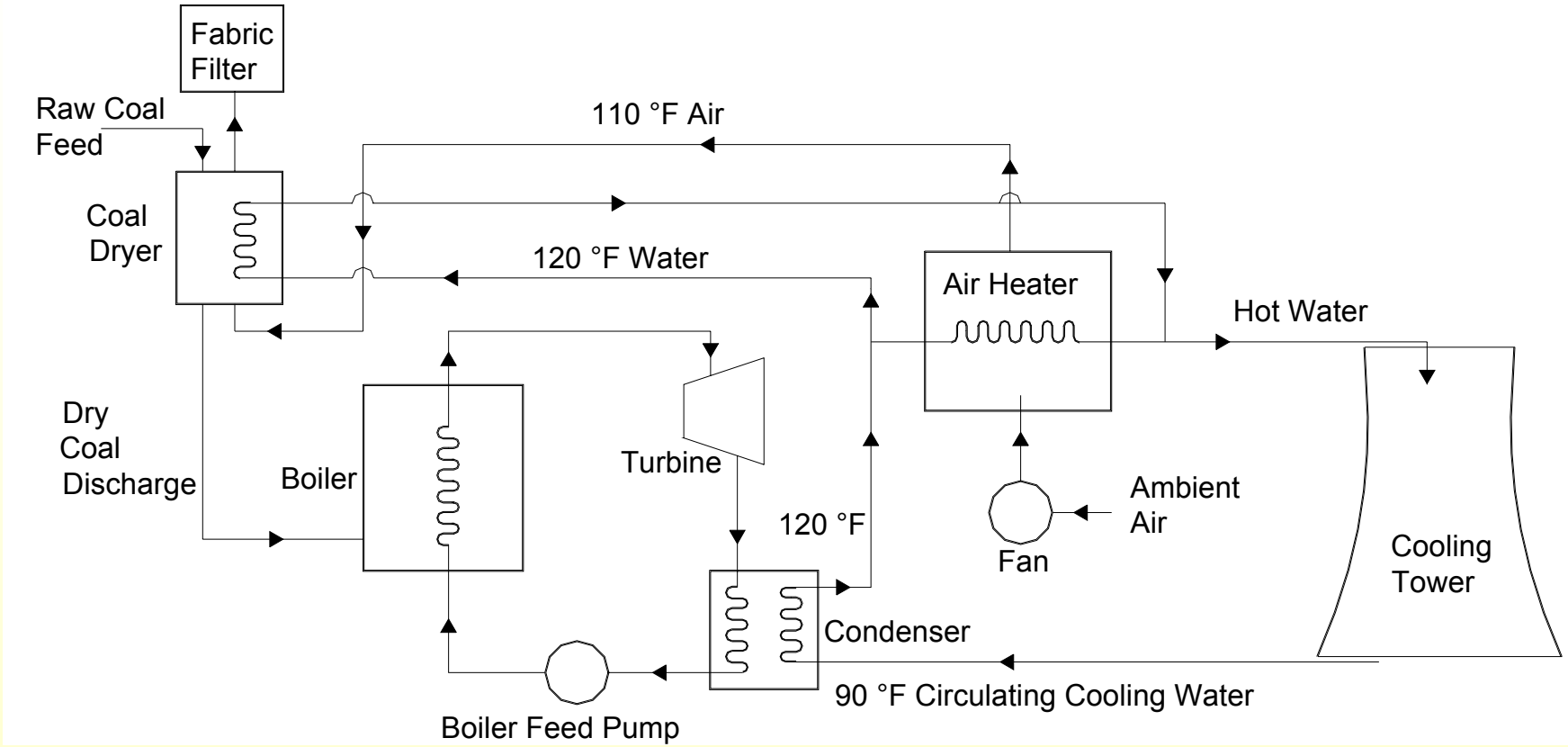
Dryers will be designed for 600 MW lignite and PRB fired power plants. Designs will be developed to dry the coal by various amounts (moisture reductions from 5 to 30 percent). Auxiliary equipment such as fans, water-to-air heat exchangers, dust collection system and coal crushers will be sized and installed capital costs and operating costs will be estimated. 600 MW lignite and PRB units with cooling towers.

TASK 5: ANALYSIS OF IMPACTS ON UNIT PERFORMANCE AND COST OF ENERGY

Analyses will be performed to estimate the effects of dryer operation on cooling tower makeup water, unit heat rate, auxiliary power, and stack emissions. The cost of energy will be estimated as a function of the decrease in coal moisture content. Cost comparisons will be made between dryer operating conditions (for example, coal particle feed size to fluidized beds and superficial air velocity for both fluidized bed and fixed bed dryers) and between dryer type.

DRYING SYSTEM DESIGN:

- Dryer Vessel, including in-bed heat exchanger
- Fans
- Water-Air Heat Exchanger
- Dust Collection
- Coal Crusher



Schematic of Plant Layout, Showing Air Heater and Coal Dryer (Version 2)

CONTROLLABLE PARAMETERS:

- Coal Top Size
- Air Velocity
- Bed Depth
- Drying Temperature

AFFECT:

- Cost of Crushing Coal
- Size of Drying Vessel
- Air Flow Rate
- Fan Power
- Moisture Content of Product

IDENTIFY OPTIMAL DESIGN AND OPERATING CONDITIONS